# CONTROL SYSTEM FOR INJECTION-MOLDING MACHINE

## BACKGROUND OF THE INVENTION

The present invention relates to a control system for an injection-molding machine. More particularly this invention concerns such a control system capable of establishing three different pressure levels in the ram operating such a machine.

An injection-molding machine has a plastifying screw rotatable and reciprocal in a housing. One end of the housing is formed with an injection head having an orifice through which plastified synthetic-resin material is ejected under pressure into a mold and the other end of the housing is provided with a laterally opening filling orifice to which granulated synthetic-resin material is chargeable.

During a normal molding cycle the granulated and unplastified synthetic-resin material is loaded into the back end of the injection-molding machine as the worm is rotated and the housing of the machine is heated. Thus the rotating worm acts as an auger and tries to force the material forwardly in the housing. Since at the beginning of the operation the forward end of the housing is closed, however, this has the effect of slowly driving the worm backwardly against the force of a ram. During this part of the cycle a relatively low pressure is maintained in the working chamber of the ram so that the ram can be forced backwardly but the plastified mass is maintained under pressure.

Once the injection-molding machine chamber is filled the pressure is greatly increased to a so-called injection pressure in the ram operating the worm. This forces the worm forward, piston-fashion to extrude the plastified synthetic-resin material from the end of the machine.

It has been found that for best molding results it is essential in the last portion of the forward advance of the worm to change the pressure from the ejecting pressure to a so-called compacting or holding pressure. It is essential for best molding results that the injecting pressure and the holding pressure be maintained within very narrow ranges, and that the change-over from the one pressure to the other be effected at a very carefully controlled and ascertained instant.

In order to operate the ram of the injection-molding machine at these three different pressure levels it is necessary to provide a programming device normally incorporating a timer operating by means of limit means carried on the injection-molding machine. All such programming arrangements have proven themselves unsatisfactory in use in that they were unable to react with sufficient speed to change over, for instance, from the injection to holding pressure at just the right instant, or the various ranges changed with time or temperature due to sensitivity of the electronic components.

## SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide an improved injection-molding system.

Another object of this invention is an improved controlled system for an injection-molding machine of the above-described mode of operation.

These objects are attained according to the present invention in an injection-molding machine having a drive ram with a pressurizable chamber and with a source of a fluid under pressure having a high-pressure side and a low-pressure side. The control system for this arrangement comprises a pressure-reducing valve having an inlet port connected to the high-pressure side of the source, an outlet port connected to the chamber and a pilot port pressurizable to control the pressure reduction across this valve. A pressure-relief valve has an inlet port connected to the chamber of the ram, an outlet port connected to the low-pressure side of the source, and a pilot port which is pressurizable to determine the pressure differential across the pressure-relief valve, as the pressure at its outlet port is always substantially zero. A pressure-control valve has an outlet side connected to the low-pressure side of the pressure-relief valve and an inlet side connected to a function control valve. This pressure-control valve is operable to maintain a first predetermined pressure differential between its inlet and outlet sides in an injecting mode and to maintain a second predetermined pressure differential between these inlet and outlet sides in a clamping mode. A function-control valve has a first connection coupled to the inlet side of the pressure-control valve and second and third connections each coupled to a respective one of the pilot ports of the pressure-reducing and pressure-relief valves. This function-control valve is operable between a filling position connecting the pilot port of the pressure-relief valve to the pressure-control valve and an injecting/holding position in which it connects the pilot port of the pressure-reducing valve to the pressure-control valve. This pressure-control valve can be connected to the pilot port of the pressure-reducing valve to establish the injecting and holding pressures in the chamber of the ram. Alternately it can be connected to the pressure-relief valve in order to control the filling pressure of the chamber of the ram. With such a hydraulic control system the reaction time is virtually instantaneous so that the change-over from injecting to holding pressure can take place at exactly the right instance as can the change-over from filling pressure to injecting pressure.

A programmer is connected to the function-control valve and to the pressure-control valve so as to pressurize the pilot ports of the pressure-reducing valve and the pressure-relief valve at the appropriate instant to the appropriate level for the desired filling, injecting, and holding pressures in the ram chamber.

According to further features of this invention the system is provided with a second pressure-reducing valve or a throttle and a cut-off valve between the outlet side of the pressure-reducing valve and the chamber. The shut-off valve may be constituted as a three-way or four-way operating valve connected to the pilot port of a piston-type cut-off valve. This operating valve is itself controlled by a programmer so as completely to shut off fluid flow from the pressure-reducing valve to the ram chamber during the filling interval. According to this invention a shunt valve, comprises another three-way or four-way valve operating a piston-type cut-off valve is connected in shunt across the throttle between the pressure-reducing valve and the ram chamber in order to allow for very fast displacement of the injection screw in the forward direction if desired.

In accordance with yet another feature of this invention, a shunt valve comprising a piston-type cut-off valve operated by a three-way or four-way operating valve is also connected across the pressure-relief valve